(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 February 2004 (19.02.2004)

PCT

(10) International Publication Number
WO 2004/015625 A1

(51) International Patent Classification[7]: G06K 19/07

(21) International Application Number: PCT/IB2003/003743

(22) International Filing Date: 8 August 2003 (08.08.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/401,762 8 August 2002 (08.08.2002) US

(71) Applicant (*for all designated States except US*): **BNC IP SWITZERLAND GMBH** [CH/CH]; Saegestrasse 5, CH-9230 Flawil (CH).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **MARTINEZ DE VELASCO, Cortina, Francisco** [MX/MX]; Sierra Amatepec #213, Lomas de Chapultepec, Mexico, D.F. 11000 (MX). **RIETZLER, Manfred** [DE/DE]; Am Alsterberg #10, Marktoberdorf 87616 (DE).

(74) Agent: **MIDGLEY, Jonathan, Lee**; Marks & Clerk, 57-60 Lincoln's Inn Fields, London WC2A 3LS (GB).

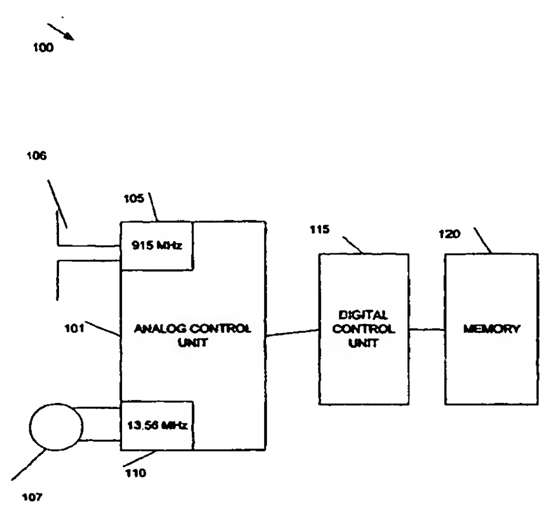
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MULTI-FREQUENCY IDENTIFICATION DEVICE



(57) Abstract: The present invention comprises a radio frequency identification device that utilizes multiple operating frequencies. In one embodiment of the present invention, one frequency (e.g., an ultra-high frequency such as 915 MHz, 800 MHz, 915 MHz, or microwave frequency such as 2.45 GHz) is used for data transmission, and another frequency (e.g., a low or high frequency such as 13.56 MHz) is used for field penetration. In another embodiment, one frequency is used for reading information received from the mufti-frequency identification device, and another frequency is used for writing to the mufti-frequency identification device. In an additional embodiment, the mufti-frequency identification device utilizes one antenna for all frequencies. In another embodiment, the multi-frequency identification device utilizes two or more antennas for different frequencies, and one common memory. In other embodiments, one or two digital parts, analog parts, antennas, and memories can be used.

WO 2004/015625 A1

DOCKET NO: 3788-009-27

TITLE OF THE INVENTION

MULTI-FREQUENCY IDENTIFICATION DEVICE

This application claims priority to provisional U.S. Patent Application Serial No. 60/401,762 filed August 8, 2002.

This application incorporates by reference provisional U.S. Patent Application Serial No. 60/401,762 filed August 8, 2002; provisional U.S. Patent Application Serial No. 60/394,241 filed July 9, 2002 and the corresponding utility U.S. Patent Application Serial No.10/615,026, filed July 9, 2003; provisional U.S. Patent Application Serial No. 60/428,257 filed November 22, 2002; U.S. Patent Application Serial No. 10/118,092 filed April 9, 2002; PCT Patent Application PCT/IB02/01439, filed April 30, 2002; German Patent Application No. 10121126.0 filed April 30, 2001; and Mexican Patent Application No. 010967 filed October 26, 2001; No. 010968 filed October 26, 2001; No. 010969 filed October 26, 2001; No. 010971 filed October 26, 2001; No. 003141 filed March 25, 2002; No. 003202 filed March 26, 2002; No. 004371 filed April 30, 2002; No. 010364 filed October 18, 2002; No. 010364 filed October 18, 2002; No. 100365 filed October 18, 2002; No. 010366 filed October 18, 2002; and 00354 filed December 16, 2002.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to transponders and methods of using transponders, and specifically to passive radio frequency identification devices and methods of using radio frequency identification devices.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 illustrates a multi-frequency, or frequency-independent identification device 100 of the multi-frequency identification device, according to one embodiment of the present invention.

Figure 2 illustrates 915 MHz system 105, according to one embodiment of the present invention.

Figure 3 illustrates 13.56 MHz system 110, according to one embodiment of the present invention.

Figure 4 illustrates a method of use 400 for the multi-frequency identification system, according to one embodiment of the present invention.

Additional features and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the Figures in which like reference numbers indicate identical or functionally similar elements.

DESCRIPTION OF THE INVENTION

Passive transponder systems are used worldwide for many identification purposes. Standard frequencies are generally 125 kHz (low frequency) and 13.56

MHz (high frequency). Additionally, new frequencies in the range of 900 MHz (ultra-high frequency or UHF) (*e.g.*, 915 MHz for USA, 868 MHz for Europe), and 2.45 GHz (microwave frequency) are also used.

Passive transponder systems have no power supply within the transponder, and are considerably less expensive than active transponders which contain other components, including a battery for power. The passive transponder is powered by an electromagnetic field of the reader. Typically a single internal antenna of the transponder is used for both data transmission and energy transmission between the reader and the transponder, using the same frequency for the data and energy transmission.

In addition, passive transponder systems are capable of "read only" or "read/write" memories, and are thus often used to perform read and write cycles.

Passive transponder systems may have multiple transmission channels, and the same frequency (*e.g.*, 125 KHz or 13.56 MHz) is generally used for all transmissions. The maximum read/write distance of these systems is limited by the limits of data transmission and energy transmission. The energy transmission channel usually has the same frequency as the data transmission because the energy and the data are transmitted simultaneously. For example, the write channel and the energy transmission channel can use the same frequency.

Depending upon application requirements, certain operating frequencies offer advantages over other frequencies. Ultra high frequency systems, using a frequency of 915 MHz, provide a read distance that is longer than low 125 KHz or high 13.56 MHz frequencies (*e.g.*, 5 meters v. a few feet). High frequency 13.56 MHz systems offer the security of limited broadcast range when writing sensitive

data to a transponder memory. Low and high frequency systems also allow greater field penetration of fluid-containing objects, such as the human body, while ultra-high frequencies are generally blocked by these objects.

The present invention includes a radio frequency identification device that uses different operating frequencies (*e.g.*, the most effective frequencies for different types of transmissions) in one identification device, thereby combining the respective advantages of each frequency. In one embodiment of the present invention, one frequency (*e.g.*, a frequency such as 868 MHz or 915 MHz to 2.45 GHz) is used for data transmission, and another frequency (*e.g.*, a low frequency such as 125 kHz) is used for proximity detection, such as in an electronic article surveillance device. In another embodiment, one frequency is used for reading information received from the identification device, and another frequency is used for writing to the identification device.

In one embodiment, the identification device utilizes one antenna for all frequencies. In another embodiment, the identification device utilizes two or more antennas for different frequencies, and one common memory. In other embodiments, one or two digital parts, one or two analog parts, and one or two antennas can be used in conjunction.

The present invention utilizes the advantages of a device (*e.g.*, a semiconductor chip) that is frequency-independent. In one embodiment, all transponder functions, such as encode/decode, modulate/demodulate, digital and analog functions, and memory, are embodied in this single device or chip. However, these functions can also be embodied in multiple chips. In one embodiment, the present invention combines the secure and proximity features of

13.56 MHz with the long read range feature of 915 MHz or 2.45 GHz. In an additional embodiment, it is possible to utilize different security levels on different channels.

In another embodiment, the present invention integrates two high frequency (HF) or two ultra-high frequency (UHF) interfaces on one chip. These two interfaces are connected to two different antennas. Each antenna is tuned to its ideal working frequency. Thus, for example, one digital part of the chip is provided that has an ability to communicate via two HF channels through two antennas. Both channels handle the data coming from the same memory. The chip detects which field the transmission is in and automatically switches the communication to the active channel.

In other embodiments of the present invention (*e.g.*, for multi application systems), different memory areas are used for the different frequency channels.

Multi-Frequency Identification Device

FIG. 1 illustrates multi-frequency identification device 100, according to one embodiment of the present invention. An example of a use of the present invention is vehicle registration. This example is used merely to illustrate the architectural overview of the present invention. Those experienced in the relevant art(s) will see that multiple other embodiments and uses are possible.

Electronic vehicle registration allows integration of a passive identification device into a license plate (*e.g.*, on the license plate or on a sticker on the license plate) of a vehicle. To identify the vehicle on the road using the identification device, in some embodiments, it is preferable to have a read distance of more than

3 meters, which can be only achieved with an ultra-high frequency (*e.g.*, 915 MHz) system.

For the write cycle to program the license plate, however, a shorter distance is sufficient, because the write cycle is typically performed only by local authorities in a nearby office. The write cycle, using 13.56 MHz, will be more secure than the read cycle in order to prevent illegal changing of the data.

The multi-frequency identification device 100 comprises: a base layer; and at least one radio frequency device comprising at least one chip and at least one antenna disposed on the at least one base layer, wherein the at least one antenna is in electrical communication with the at least one chip. In one embodiment, the chip can be a frequency-independent chip. In this case, a single manufactured silicon chip, when properly connected and matched to an appropriate antenna, will operate at any of the relevant frequencies assigned for identification devices. In other embodiments, the chip can also be a one-frequency or multi-frequency chip. In these cases, the chip is uniquely designed and characterized to operate with a specific antenna at one or a few specific frequencies.

In one embodiment, the multi-frequency identification device 100 is a radio frequency system that comprises an analog control unit 101, which is a dual interface with the combination of two frequencies: a 915 MHz or 2.45 GHz system 105; and a 13.56 MHz system 110. The 915 MHz system 105 is used, for example, for a reading data function that enables speed. In one embodiment, the 915 MHz system 105 includes a dipole antenna 106. The 13.56 MHz system 110 is used, for example, for the writing (personalization) of the identification information for the

vehicle having the license plate. In one embodiment, the 13.56 MHz system 110 includes a coil antenna 107 (i.e., a wound spiral of insulated wire).

The multi-frequency identification device 100 also includes a digital control unit 115 and memory 120. The analog control unit 101 is a device or circuit that is continuously varying in signal strength or quantity, rather than based on discrete units, such as the binary digits 1 and 2. The digital control unit 115 is a device or circuit that is based on discrete units, such as binary digits 1 and 0.

Figure 2 illustrates 915 MHz or 2.45 GHz system 105, according to one embodiment of the present invention. The 915 MHz system 105 comprises: AC/DC converter 205, power supply control unit 210, instruction sequencer 215, and memory 220. An AC/DC converter 205 is a device that receives an alternating current (AC) and converts it to direct current (DC). A power supply control 210 is a device which regulates voltage and current to protect an apparatus from power surges and low power. An instruction sequencer 215 is a device that queues instructions to be sent to a chip's internal memory. EEPROM (Electrically Erasable Programmable Read-Only Memory) memory 220 stores data. In one embodiment, the analog control unit, the digital control unit, and memory units comprise a single integrated circuit chip (*e.g.*, the RFID chip manufactured by SCS Corporation, San Diego, CA).

Figure 3 illustrates 13.56 MHz system 110, according to one embodiment of the present invention. 13.56 MHz system 110 comprises: a modulator 305, an AC/DC converter 310, a codifier 325, a decoder 315, a power supply control unit 320, an instruction sequencer 330, a security administrator 335, a cryptographic block 340, and memory 345. A modulator 305 is a device that receives baseband

signals from an antenna. An AC/DC converter 310 is a device that receives an alternating current (AC) and converts it to direct current (DC). A codifier 325 is a device for encoding information received so that it may be utilized by another device or protocol. A decoder 315 is a device that decodes information from the encoder output so it may be used by another device or display. A power supply control 320 is a device which regulates voltage and current to protect an apparatus from power surges and low power. An instruction sequencer 330 is a device that queues instructions to be sent to a chip's internal memory. A security administrator 335 is a device that checks and validates the cryptographic keys that will be sent to the cryptographic block. A cryptographic block 340 is a device that stores the security keys. These keys are checked and validated to grant or deny access to the memory chip. EEPROM memory 345 stores data.

Method of Using Multi-Frequency Identification Device

Figure 4 illustrates a method of use 400 for the multi-frequency identification device 100, according to one embodiment of the present invention. In step 405, a first transmission at frequency 915 MHz takes place. Thus, for example, when a vehicle approaches a reader, the first transmission takes place. In step 410, the antenna 106 of the 915 MHz system 105 receives the first transmission. Thus, for example, the antenna 106 of the 915 MHz system 105, which is embedded on the vehicle license plate, receives the transmission from the reader. In step 415, the first transmission powers the multi-frequency identification device. Thus, for example, the reader's transmission powers the multi-frequency identification device on the license plate. In step 420 (*e.g.*, when the vehicle is

closer to the reader), a second transmission at frequency 13.56 MHz takes place. Thus, for example, when a vehicle approaches a reader, the second transmission takes place. In step 425, the antenna 107 of the 13.56 MHz system 110 receives the second transmission. Thus, for example, the antenna 107 of the 13.56 MHz system receives information (*e.g.*, authorization to pass a border) from the reader/writer and stores it.

Conclusion

The present invention is described in terms of the above embodiments. This is for convenience only and is not intended to limit the application of the present invention. In fact, after reading the description of the present invention, it will be apparent to one skilled in the relevant arts how to implement the present invention in alternative embodiments.

In addition, it should be understood that the Figures described above, which highlight the functionality and advantages of the present invention, are presented for example purposes only. The architecture of the present invention is sufficiently flexible and configurable, such that it may be utilized in ways other than that shown in the Figures.

WHAT IS CLAIMED IS:

1. An identification device, comprising:

at least one base layer;

at least one radio frequency identification device comprising at least one chip and at least one antenna disposed on the at least one base layer, wherein the at least one antenna is in electrical communication with the at least one chip;

wherein the radio frequency identification device operates using at least a first radio frequency and a second radio frequency.

2. An identification device, comprising:

at least one base layer;

at least one radio frequency identification device comprising at least one frequency independent chip and at least one antenna disposed on the at least one base layer, wherein the at least one antenna is in electrical communication with the at least one frequency independent chip;

wherein the radio frequency identification device operates using at least a first radio frequency and a second radio frequency.

3. The identification device of Claim 1 or 2, wherein the first radio frequency is a low frequency, and the second radio frequency is a high frequency.

4. The identification device of Claim 1, 2 or 3, wherein the second radio frequency is a high frequency used for at least one of:

data transmission;

energy transmission;

reading data;

writing data; and

reading and writing data.

5. The identification device of Claim 1, 2, 3 or 4, wherein the first radio frequency is a low frequency used for at least one of:

data transmission;

energy transmission;

reading data; and

reading and writing data.

6. The identification device of any one of Claims 1-5, wherein the radio frequency identification device utilizes one antenna for the first radio frequency and the second radio frequency.

7. The identification device of any one of Claims 1-5, wherein the radio frequency identification device utilizes a separate antenna for each radio frequency.

8. The identification device of any one of Claims 1-5, wherein the radio frequency identification device utilizes a different antenna configuration for each radio frequency.

9. The identification device of any one of Claims 1-8, wherein the radio frequency identification device utilizes one common memory area for the first radio frequency and the second radio frequency.

10. The identification device of any one of Claims 1-8, wherein the radio frequency identification device utilizes a separate memory area for each radio frequency.

11. The identification device of any one of Claims 1-8, wherein the radio frequency identification device utilizes different memory areas for each different radio frequency.

12. The identification device of Claim 1 or 2, wherein the first radio frequency is an ultra-high frequency and increases maximum operating distance of the identification device.

13. The identification device of any one of the preceding claims, wherein the second radio frequency is a high frequency.

14. The identification device of any one of the preceding claims, wherein the second radio frequency is a high frequency and increases security.

15. The identification device of any one of the preceding claims, wherein the first radio frequency and the second radio frequency use different security levels.

16. The identification device of any one of the preceding claims, wherein the radio frequency identification device comprises at least two high frequency interfaces on the chip.

17. The identification device of any one of the preceding claims, wherein the radio frequency identification device comprises two ultra-high frequency interfaces on the chip.

18. The identification device of Claim 16, wherein each of the high frequency interfaces is connected to a corresponding antenna, whereby each antenna is tuned to an optimal working frequency.

19. The identification device of Claim 17, wherein each of the ultra-high frequency interfaces is connected to a corresponding antenna, whereby each antenna is tuned to an optimal working frequency.

20. The identification device of Claim 19, wherein a digital part of the chip has an ability to communicate via two frequency channels through two antennas.

21. The identification device of Claim 20, wherein the first radio frequency channel and the second radio frequency channel handle data coming from the same

memory, and the chip detects which field the transmission is in and automatically switches the communication to the active channel.

22. The identification device of any one of claims 1-21, further comprising additional radio frequencies, different from the first and second radio frequencies.

23. A method of identifying an entity, comprising:

receiving a first transmission at a first radio frequency using at least one antenna;

powering a multi-frequency identification device associated with the entity with the first transmission; and

receiving a second transmission at a second frequency using the at least one antenna.

24. The method of Claim 23 or 24, wherein the first radio frequency is a high frequency, and the second radio frequency is an ultra-high frequency.

25. The method of Claim 23, 24 or 25, wherein the second radio frequency is an ultra-high frequency used for at least one of:

data transmission;

energy transmission;

reading data;

writing data; and

reading and writing data.

26. The method of any one of Claims 23-25, wherein the first radio frequency is a hi frequency used for at least one of:

data transmission;

energy transmission;

reading data;

writing data; and

reading and writing data.

27. The method of any one of Claims 23-26, wherein one antenna is utilized for the first radio frequency and the second radio frequency.

28. The method of any one of Claims 23-26, wherein a separate antenna is utilized for each radio frequency..

29. The method of any one of Claims 23-28, wherein one common memory area is utilized the first radio frequency and the second radio frequency.

30. The method of any one of Claims 23-28, wherein a separate memory area is utilize for each radio frequency.

31. The method of any one of Claims 23-28, wherein different memory areas are utilized for each different radio frequency.

32. The method of Claim 23, wherein the first radio frequency is a low frequency and increases maximum operating distance of the identification device.

33. The method of Claim 23, wherein the second radio frequency is a high frequency.

34. The method of Claim 23, wherein the second radio frequency is a high frequency and increases security.

35. The method of any one of Claims 23 to 34, wherein the first radio frequency and the second radio frequency use different security levels.

36. The method of any one of Claims 23 to 35, further comprising additional radio frequencies, different from the first and second radio frequencies.

FIGURE 1

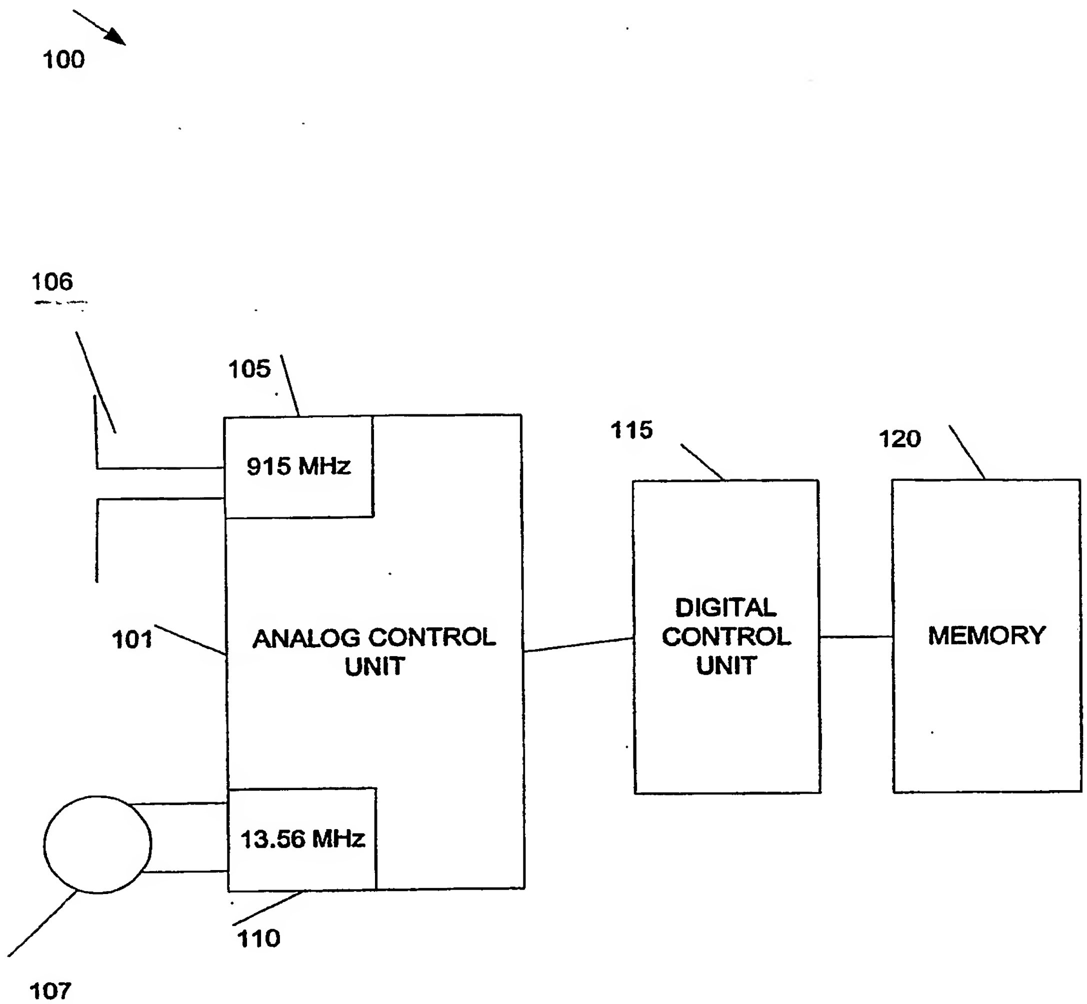

100
106
105
915 MHz
115
120
101
ANALOG CONTROL UNIT
DIGITAL CONTROL UNIT
MEMORY
13.56 MHz
110
107

FIGURE 2

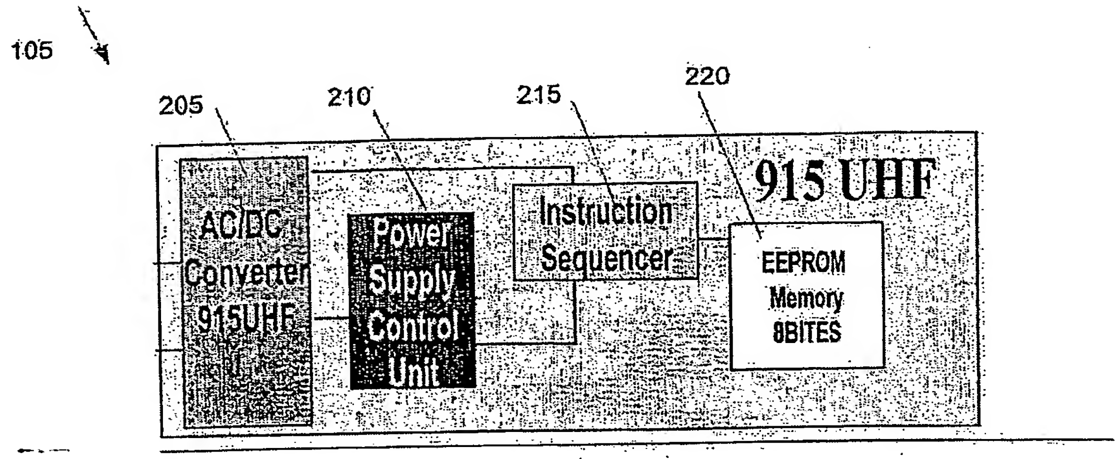

105
205
210
215
220
915 UHF
AC/DC
Converter
915UHF
Power
Supply
Control
Unit
Instruction
Sequencer
EEPROM
Memory
8BITES

FIGURE 3

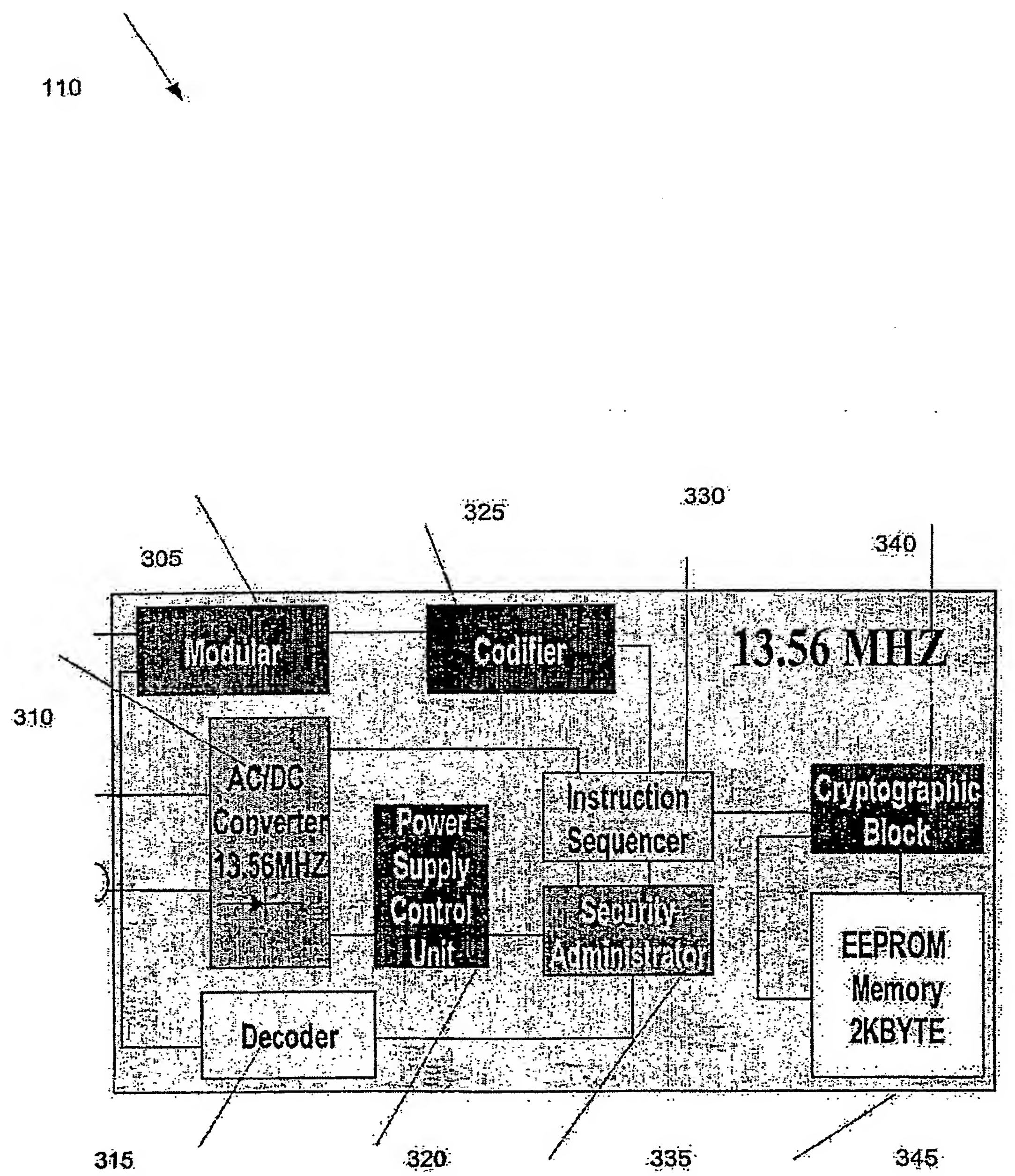
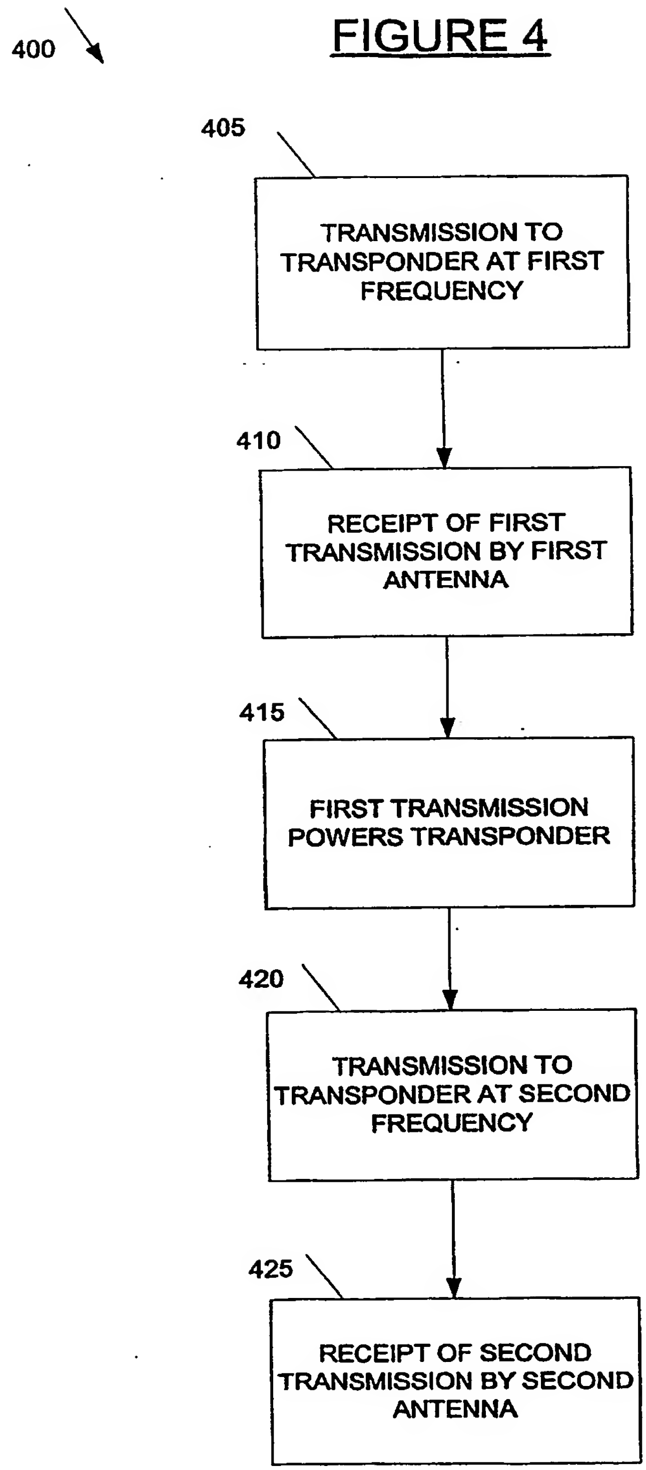

110
305
325
330
340
310
Modular
Codifier
13.56 MHZ
AC/DC Converter 13.56MHZ
Power Supply Control Unit
Instruction Sequencer
Security Administrator
Cryptographic Block
EEPROM Memory 2KBYTE
Decoder
315
320
335
345

FIGURE 4


400
405
TRANSMISSION TO TRANSPONDER AT FIRST FREQUENCY
410
RECEIPT OF FIRST TRANSMISSION BY FIRST ANTENNA
415
FIRST TRANSMISSION POWERS TRANSPONDER
420
TRANSMISSION TO TRANSPONDER AT SECOND FREQUENCY
425
RECEIPT OF SECOND TRANSMISSION BY SECOND ANTENNA

INTERNATIONAL SEARCH REPORT

PCT/IB 03/03743

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K19/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 426 667 A (VAN ZON BERNARDUS C M) 20 June 1995 (1995-06-20) column 3, line 38 -column 4, line 17; figure 4 column 7, line 4 - line 24	1-36
X	FR 2 779 847 A (REGIE AUTONOME TRANSPORTS) 17 December 1999 (1999-12-17) abstract; claim 1; figure 1	1-36
X	EP 1 209 615 A (ADVANCED MICROWAVE ENGINEERING) 29 May 2002 (2002-05-29) column 3, line 17 -column 4, line 35; figure 1	1-36

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November 2003	03/12/2003

Name and mailing address of the ISA	Authorized officer
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PCT/IB 03/03743

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 24628 A (TAGMASTER AB ;GUNNARSSON STAFFAN (SE)) 10 July 1997 (1997-07-10) page 3, line 25 - line 33; claim 1; figures 4-7	1,3-15, 23-36

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